Art. XI.—*Notes on Certain Metamorphic and Plutonic Rocks at Omeo.*

By A. W. Howitt, F.G.S.

In writing on the subject of the Metamorphic Rocks at Ensay * I said that the conclusions to which their study had led me were also those to which I had been brought by the examination of similar phenomena in the Omeo district, where the relations of the sedimentary, metamorphic, and plutonic rocks may be observed and studied on a much wider scale. In the present paper, I desire to bring under notice certain observations which I have made on the relations of the metamorphic and plutonic rocks in one part of the valley of the Livingstone Creek.

These notes refer only to a part of the Omeo district, that is to say, to a strip of country extending from the Tongeo Gap in the Great Dividing Range to near the junction of the Livingstone Creek, with the Mitta Mitta River at Hinnomunjie.

The road from Ensay and from the valley of the Tambo River ascends the Great Dividing Range from Tongeo, by way of the Tongeo Gap, at an elevation of 2800 feet above sea level, and thence follows the slopes of the eastern side of the Livingstone Valley to the township of Omeo, at about 500 feet below the elevation of the Gap.

To the right-hand of the Tongeo Gap, in going to Omeo, are the Bowen Mountains, rising to some 1500 feet or more above it. These mountains are almost wholly composed of highly inclined and more or less altered sediments, which have, in places, still retained the familiar facies of the older palæozoic or goldfields series of this district. The wide sloping valley falling from them towards Livingstone Creek is composed of varieties of regional metamorphic schists together with masses of intrusive granites and quartz diorites, the former being the most prevalent.

From near the Tongeo Gap, and running in a direction which approximates to N. 30° W., that is to say, to the mean strike of the lower Silurian formations, there is a more or less well-marked contact of the plutonic and altered sedimentary

* "The Sedimentary, Metamorphic, and Igneous Rocks of Ensay." Transactions Royal Society of Victoria, vol. xxii, p. 64.

rocks, which crosses Livingstone Creek just below the northern end of the Hinnomunjie Morass, and thence extends probably to the Mitta Mitta River, if not beyond. The total distance of the contact which I have observed is not less than ten miles.

Speaking generally, the rocks on the north-east side of this contact are varieties of metamorphosed sediments, which, at a distance from it, still retain the outward semblance of the alternating argillaceous and arenaceous beds of the Silurian formations, while near to the contact, they are in places so metamorphosed as no longer to be recognisable when seen in hand samples. On the south-western side of the contact the rocks are almost wholly crystalline intrusive rocks, mostly granites, and with, in places, small areas of gneiss.

This contact represents a great fault, the amount of down-throw on the north-eastern side having brought the sedimentary strata within the influence of the intrusive rock masses. It is not possible to say how much has been the amount of down-throw, for there is not any standard which may be taken for reference. The sedimentary rocks have been almost completely denuded for long distances on the south-western side of the contact, and those that remain in the nearest localities, as for instance on Mount Livingstone, or in Mountain Creek, are so much metamorphosed as to afford no measure of comparison. Nor can any data be obtained from the relative position of the contact planes in those places and at Wilson's Creek or Hinnomunjie Morass.

The sections and diagrams which accompany these notes, together with the analytical examinations of the rocks collected, will give further insight into the interesting features of this locality.

Hinnomunjie Morass.—The line of contact, as I have already said, crosses Livingstone Creek at a short distance below the Hinnomunjie Morass, and thence extends, I know not how far, towards or beyond the Mitta Mitta River. The line of contact is not a regular one when locally examined, yet, when traced for some distance in its course, it will be found to maintain a general direction approaching to north-west. Moreover, on looking across the undulating country crossed by it, the difference in outline of the schist hills on the one side, and of the granite hills on the other, is often quite perceptible to the accustomed eye. The local irregularity in the contact line is due to the protuberance of the granites into the tracts of schist, in promontory-like extents, which are again connected with lesser masses, or with dykes and veins which pass across or between the beds of schist. Moreover, there are numerous places where greater or less extents of granitic rocks have been exposed in the schist areas, especially in the Wilson's Creek district, by denudation at distances of more than a mile from the granite contact.

The manner of the contact between the granites and the schists will be understood from the following descriptions :—

The first sample of contact which I shall note, is situated about a mile from the northern end of the Hinnomunjie Morass, in a small gully which runs down to Livingstone Creek from the west side. The actual contact has been laid bare in a horizontal section. The schists are nearly vertical, on a strike of N. 55° W. They are greyish in colour, and the less quartzose beds are micaceous and glistening, and very frequently nodular in character. Irregular veins of quartz follow the strike, or cut across the beds. The granites which are on the western side of the contact extend from it into the schists, and also pass as dykes between the beds, or appear as apparently isolated masses at a distance, surrounded by them. The intrusion of the granites does not appear to have much bent or contorted the beds of schist, which, however, are cut off across the strike, as well as being in places detached in portions from the main mass.

The essential features of this contact are given in Fig. 1, Plate I., and I collected examples of the schists, and of the granites, as to which the following details will give information :—

The first samples illustrate the micaceous and the quartzose beds which alternate with each other just as do the argillaceous and quartzose beds of the local Silurian sediments. The first sample is of a grey-coloured, very fine grained mica schist. It is much corrugated on a small scale, and is distinctly nodular. Under the lens one can make out colourless mica in small flakes, some black mica in less amount, and also some minute crystals of black tourmaline. Examined as a thin slice under the microscope, the main mass of the rock is seen to be of muscovite mica, intermixed with a brown magnesia mica. In places the muscovite is the sole mica; in others the magnesia mica preponderates, and there are also places where the plates of both of the micas are larger than the average. Throughout the whole slice there are very numerous small prisms of tourmaline, which are translucent in tints of brown, the O ray being brown and the E ray being almost colourless. The prisms are mostly arranged with their C axis in the plane of the slice, and therefore, I observed but few cross sections. So far, however, as I could observe, the prisms are mostly six-sided, and are hemi-hedrally terminated. The size of the prisms varies from ·08 inches down to ·02 inches in length, and from ·04 inches to ·01 inches in width. Many of the crystals are much eroded, and also include what appear to be small masses of quartz.

The second sample examined is of a somewhat fissile grey coloured schist, tinted in places with ferruginous stains. The foliations are glistening with minute plates of muscovite, and under the lens one can observe, in addition to them, flakes of brown mica, and numerous prisms of tourmaline of minute size. There are slight traces of nodular structure in this schist. An examination of a thin slice of this rock shows that it is composed of a considerable amount of quartz in grains, intermixed with flakes of muscovite and magnesia mica, the latter being strongly pleochroic. There are great numbers of minute tourmaline crystals distributed throughout the slice. In places the magnesia mica preponderates over the muscovite, as was the case in the sample last described. The principal, if not the only, difference in the two samples, is that in the latter quartz is in considerable percentage, and that the magnesia mica occurs in crystals and not in overlapping plates. As I have shown in Fig. 1, Plate I., portions of the schists have been detached, and are included in the granite. In order to see what changes had been effected by the action of the magma upon such fragments of the sedimentary rocks, I examined one such sample (*c* in Fig. 1, Plate I.) with the following results:—

The hand sample is a finely crystalline rock, having in places a schistose arrangement; but taken as a whole, it much resembles some of the very crystalline dark-coloured varieties of hornfels. Under the pocket lens it can be made out to be a mixture of quartz grains, and very numerous minute, splendent, rather short prisms of tourmaline of a black colour. In a thin slice under the microscope, this rock is seen to be composed of quartz grains and very numerous crystals of tourmaline, which is transparent in tints of brown. These crystals do not lie in any definite direction in the slice, although they form bands in it, thus producing a schistose appearance. They are mostly short and rather stout, prismatic crystals, three, six, or nine-sided, and hemi-hedrally terminated. The dimensions of these crystals are about the same as those last described. They are, and especially the larger ones, much eroded and cavernous, and include numerous particles of quartz. The crystals are pleochroic, the E ray being nearly colourless, while the O ray is a dark golden brown. These observations were further confirmed by an examination of a number of these beautifully splendent crystals which I isolated by means of hydrofluoric acid. The main mass of this rock is composed of numerous grains of quartz, with a few small grains of triclinic felspar.

It seems to me that this rock represents a portion of schist in which the bases have been converted into tourmaline, with also an access of silica as quartz.

The Muscovite granite at this contact varies much in grain. In some parts, the constituent minerals are up to an inch across, while as to others, all that can be said is, that it is slightly coarser than that of the average rocks of the neighbourhood.

I separated samples of the felspar, mica, and quartz for examination.

The felspar is yellowish in colour. In places, it is somewhat intergrown with quartz, after the manner of "graphic granite." Under the pocket lens it also shows those irregular veinlets of a second felspar on OP (001), and $\infty \bar{P} \infty$ (010), which indicate a microperthite. I found on examining a thin slice prepared from the most perfect cleavage (OP), that this felspar is a well-marked example, the albite veins being very characteristic, as well as the twinned structure of the microcline, which is the form of the potassa felspar.

A slice from the less perfect cleavage (∞ ∞) showed me also the familiar appearance of irregular veinlets of albite, traversing the slice at angles between 60° and 65° to the trace of the perfect cleavage. A second set of veinlets were also interposed in the plane OP, and which in places connected with the other series. The inclusions in this felspar are confined to grains of quartz, and rarely plates of muscovite. Through the kindness of Mr. J. C. Newbery, C.M.G., Mr. Jas. C. Fraser most obligingly made the subjoined quantitative analysis of this felspar in the laboratory of the Technological Museum:—

ANALYSIS No. 1.—MICROPERTHITE.*

$Si.O_2$	62·13
$Al._2O_3$	24·35
$Fe._2O_3$	tr.
$Na._2O$	6·66
K_2O	8·31
H_2O	·50
	101·95

The mica is the usual silvery coloured muscovite found in these rocks, in plates, and in irregularly shaped crystals, having an hexagonal, that is to say, a modified rhombic outline. When least altered, the cleavage plates have a slightly smoky tint by transmitted light. The optical characters of this mica are as usual, and it is according to Reusch's test, a mica of the second order.

I subjoin a quantitative analysis of this mica:—

ANALYSIS No. 2.—MUSCOVITE.

Fl	·15
$Si.O_2$	44·67
$Al._2O$	37·44
$Fe._2O_3$	·48
$Fe.O$	·91
$Ca.O$	·26
$Mg.O$	·42
K_2O	10·90
$Na._2O$	1·24
H_2O	3·76
	100·23
Hygroscopic Moisture ...	2·18
Sp. gr.	2·758

The quartz of this granite is somewhat glassy in appearance, and contains numerous fluid cavities without bubbles. It shows cloudy obscuration when examined by polarised light, indicative of strain.

* The grains of free quartz were picked out from the sample before analysis.

The less coarse parts of this granite mass, though still large in grain, is of such a texture that a fairly correct estimate of its composition can be made by examining a thin slice of good extent.

I found in it muscovite in broad crystals, with irregularly bounded planes parallel to the C axis. Some individuals included grains of quartz. The felspar is in less amount, being mainly orthoclase, with a smaller proportion of plagioclase, which occurs in ill-formed crystals with irregular twinning. The quartz is in large amount, and of the same character as that spoken of before. In the mica, felspar, and quartz there are numerous small spheroidal masses of black opaque iron ore, which is probably of secondary origin. This rock is, therefore, to be classed as a coarse-grained muscovite granite.

Another interesting exposure of the contact is laid open in a gully somewhat nearer to the Hinnomunjie Morass. Here the surface details are supplemented by a vertical section in the banks of the gully immediately adjoining. This exposure is, I think, a little to the eastward of the general line of contact, if one may assume that at this spot it is at the extreme western extremity of the masses of schist. But the schists and the granites are so much interlocked that it is not always safe in the absence of a detailed survey to speak with certainty as to any particular spot in this line being the main contact. The schists are here surprisingly regular in their strike and dip considering their relation to the granites. They are alternations of somewhat narrow micaceous and quartzose beds. They are always at a high angle of dip, and frequently vertical on a strike of near N. 45° W. Fig. 2, Plate I., represents diagrammatically the relations of these schists, and of the granites which are in contact with them. It will be seen that the granites have come up as veins or dykes between the schist-beds, and that at the principal contact these intrusive rocks are massive, and fill a space which was once occupied by the schists which are, as I have represented, cut off sharply, and in places are more or less included in the intrusive rock.

In proceeding across the strike of the schists, beyond the line of section and in a north-easterly direction, the granite veins decrease in number, and the schists are less altered, until at perhaps a distance of a mile they have much the normal appearance of the argillaceous schists of Reedy Creek.

The mineralogical characters of these schists will be understood better from the following examples. The letters prefixed to the descriptions refer to those appended to the diagram Fig. 2, Plate I.

(*a*) Nodular mica schist striking N. 30°-40° W. The beds at this place are not all of them nodular, and they vary also in colour and in the relative amounts of quartz and mica. This sample I examined in a thin slice. I found the main mass of the rock to be a mixture of brown magnesia mica, and of colourless muscovite in small overlapping plates. In this are very numerous short, stout, light-coloured crystals of tourmaline from ·004 x ·002 inches down to ·0015 x ·001 inches in dimensions. There is a considerable amount of black iron ore scattered throughout the slice. No quartz is visible in the several slices examined. I have to thank Mr. Jas. C. Fraser for the subjoined analysis of this rock :—

Analysis No. 3.—Mica Schist.

$Si.O_2$	58·87
$Al._2O_3$	16·95
$Fe._2O_3$	8·62
$Fe.O$	3·93
$Ca.O$	·97
$Mg.O$	2·32
K_2O	5·98
Na_2O	1·48
$Li._2O$	tr.*
B_2O_3	tr.
	99·12

A second sample from the same place (*a* Fig. 2, Plate I) is of one of the quartzose beds. In the hand sample it is a somewhat fissile schist of a greyish to yellowish colour, and the foliations very glistening with plates of muscovite. Under the lens can be seen plates of rather pearly mica, very little brown magnesia mica, and numerous crystals of tourmaline can be made out. Under the microscope a thin slice of this rock shows a far greater amount of quartz than there is in those beds of which the last described is a sample. With the quartz grains there is a colourless mica, and there are numerous tourmaline crystals of somewhat larger size than those in the last-mentioned rock. These crystals lie mostly

* Determined by spectroscope only.

in the micaceous foliations, and are generally broken across. The principal difference between this rock and the last one described is in the scarcity comparatively of magnesia mica, and in the large amount of quartz in grains of various sizes.

The subjoined analysis was kindly made for me in the laboratory of the Technological Museum, by Mr. Jas. C. Fraser:—

ANALYSIS No 4.—QUARTZOSE MICA SCHIST.*

$Si.O_2$	72·60
$Al._2O_3$	9·03
$Fe._2O_3$	10·00
$Fe.O$	1·05
$Ca.O$	·50
$Mg.O$	3·12
K_2O	2·44
Na_2O	2·62
H_2O	·50
	101·86

I selected a third sample from a quartzose bed adjoining a dyke at *c*, Fig. 2, Plate 1. It is composed of rather large rounded to angular grains of quartz, full of inclusions, and with fluid cavities without bubbles. The inclusions are mostly minute rounded flakes of dark brown mica, such as I have frequently observed in quartzose hornfels at Swift's Creek and in other parts of North Gippsland. Besides the quartz there are flakes of muscovite in less amount than the numerous small, greenish-coloured prisms of tourmaline. In order to complete the comparison of varieties of these schist beds, I selected a fourth example, being one taken from close to the contact at the place marked (*e*) in the diagram section, Fig. 2, Plate I. This sample is strongly nodular, but otherwise much resembles in appearance the second example at (*a*.) Judging from the example of a thin slice, this rock is composed of quartz in angular grains, scattered through a ground mass of muscovite mica. Fluid inclusions are common in the grains of quartz, which differ much in size. Tourmaline crystals of minute size are also numerous, arranged parallel to the foliations. Most of these crystals have, as in other samples, been broken across the

* I found the specific gravity of a sample of this rock to be 2·723.

prism. These samples of the schists sufficiently describe the character of all the beds shown in the section, the only difference being that some are more nodular than others, or that in places the quartzose beds predominate over the micaceous ones, or *vice versâ*.

An inspection of the diagrams given, which sufficiently well copy the reality, shows that the schists have been invaded by the granites, which, in places, fill spaces at one time occupied by the schists, and in other places, at further distances, have penetrated between the beds and more rarely across them. Where the contact line is well marked, the schists are cut across, and the granites abut against the truncated ends, and also include fragments of the beds which have been detached, and have become surrounded by the magma. The general character of these granites in mass is a rather coarse crystalline, or crystalline granular compound of felspar, muscovite, and quartz, analogous to that described previously at *p*. The dykes and veins which lie between the schist beds are, however, as a rule, much coarser in structure than the granite masses, and may, in some cases, be rightly designated as Pegmatite. But since this name has, to some degree, become associated with the conception of dykes which are not, strictly speaking, igneous and intrusive*, it may be well to use the general term "muscovite granite." These dykes vary in the locality taken as an illustration from 6 inches up to 36 inches in width. With the larger ones I found quartz veins to be associated, thus recalling the "plutonic quartz veins" which I have spoken of elsewhere †. In this locality these veins seem so far to have proved entirely barren of gold or ores of metals. In Fig. 1, Plate II., I have sketched one of the dykes of muscovite granite which occur in the section described. I chose this dyke for the reason that it represents the fair average sample, while at the same time it is, in parts, not too coarse in texture for a thin slice for microscopic examination. It is composed of felspars of two kinds, muscovite mica and quartz. The potassa felspar is in

* Kalkowsky remarks as follows :—"Es ist nun aber zu beachten dass solche Pegmatite fast stets 'gang granite' sind, also massen deren anogene Entstehung zehr zeifelhaft ist die viel mehr durch mancherlei chemische und mechanische Processe unter uns unbekannten Verhält nissen gebildet worden sein mögen."—*Elemente der Lithologie*, p. 66.

† Notes on the Area of Intrusive Rocks at Dargo. Transactions Royal Society of Victoria, Vol. XIII., p. 152.

comparatively large irregularly-shaped masses, without any striation, and obscuring in partial fields. As there is no trace of cleavage, and as there are no bounding planes developed, observations as to the angle of obscuration could not be made. The percentage of potassa in the subjoined analysis renders it, however, most likely that these felspars are as I have classed them. Besides these larger individuals, there are also smaller fragments of the same. The other felspar is a plagioclase in much wasted crystals. The only obscuration angles which I could measure with any confidence, gave 2° approximately on OP (001), and 11° on $\infty\bar{P}\infty$ (100.) The mode of twinning resembles that of oligoclase.

Muscovite mica is in large crystals which have been much corroded at the sides. Where the section cuts the crystal at a slight angle with the base, the slice has a peculiar mottled-appearance, due to the overlapping of numerous consecutive cleavage plates. But where the section coincides with the basal cleavage, the slice is optically perfectly homogeneous, and polarizes with uniform tint of colour. There are no inclusions, and the mica seems to me to be of the same period of formation as the felspar, but to be younger than the quartz. The quartz is in large masses, filling in all spaces, and including portions of broken up felspars of both kinds, and also small flakes of muscovite. I made a quantitative analysis of a portion of this dyke which was apparently but little decomposed, but also somewhat more quartzose than the part examined under the microscope :—

Analysis No. 5.—Muscovite Granite.

$Si.O_2$	76·10
$Al._2O_3$	15·95
$Fe._2O_3$	tr.
Ca.O	·23
Mg.O	·11
K_2O	3·27
$Na._2O$	2·90
H_2O	1·16
	99·72
Hygroscopic Moisture ...	·18
Sp. gr.	2·673

At (*e*) in the section Fig. 2, Plate I., there is a close-grained dyke of a dark-greenish colour, lying between the schists, and about three feet in thickness.

When examined in a thin slice, I observed that it was extremely altered from the usual character of such dykes in this district, and of the original structure but little remained. In parts there had been an extensive deposition of quartz in irregularly-formed concentric radial crystals, forming masses which, when rotated between crossed nicols, showed strong traces of a black cross. Here and there in the portions outside these quartz masses, I could trace the outlines of former lath-shaped crystals of felspar, scattered among numerous groups of grains and tufts of a dark-green mineral, which I did not find to be sensibly dichroic. Were it not for this, I should be inclined to consider it one of the chlorite groups of minerals. Mr. Jas. C. Fraser found in an examination of a sample of this rock, ·05 per cent. of boracic acid. All that I can say is, that it probably in its original condition was a diabase porphyrite, and that it seems to have been subjected to metamorphism at the same time with the schists enclosing it.

Before speaking generally as to the conclusions to be drawn from a consideration of the phenomena observed at the contact of the granites and the mica schists in the two localities now described at Hinnomunjie Morass, it will be well to review slightly different, and yet analogous appearances, in connection with another part of the same contact, which can be studied at Wilson's Creek, at a distance of several miles south east from the locality which I have now described.

Wilson's Creek rises in the Bowen Mountains, and in the spur, which runs from it in a north westerly direction over Mount Cook, towards Livingstone Creek. It crosses the line of contact of the granites and schists about a mile and a half above its junction with Livingstone Creek. Thus the upper part of its course is over the metamorphosed schists, and the lower over the granites.

In Fig. 3, Plate I., I have given a diagrammatic section along that part of its course which covers the most important features.

In the following descriptions, the letters used at the commencement of the several paragraphs refer to that section :—

(*a.*) Spotted schists dipping N. 60°, E. at 70°. These beds conform in their strike and in their alternation of quartzose and fine-grained beds, with the less altered formations in the same sequence in the Bowen Mountains, which can be again followed across their strike still further to the eastward, to where in the Tambo Valley, between Tongeo and Bindi, they have all the familiar facies of the Silurian strata of the district. I regard these schists as being metamorphosed lower palæozoic sediments, and in all probability of lower Silurian age.

Under the microscope, I found a thin slice prepared from one of the fine-grained beds, to be a minute mixture of small flakes of a colourless alkali mica, with a very little magnesia mica of a yellowish colour, and a small amount of quartz in grains of minute size.

Throughout the whole mass, there is much graphite distributed in minute specks, which in places are aggregated into small masses. Of this rock I made the subjoined quantitative analysis :—

Analysis No. 6.—Mica Schist.

C	3·32*
P_2O_5	·10
$Si.O_2$	64·00
$Al._2O_3$	19·82
$Fe._2O_3$	3·50
Ca.O	·32
Mg.O	2·14
K_2O	4·41
$Na._2O$	1·10
H_2O	2·23
	100·94
Hygroscopic Moisture ...	·85
Sp. gr.	2·651

I also examined a quartzose schist which adjoined the above. I found it to be composed mainly of grains of quartz, some of which contain numerous fluid cavities. Surrounding, and lying between the quartz grains are small ragged flakes of magnesia mica, which are much bleached in colour, and

* As this percentage of graphite appeared to me to be high, I made a second determination for control, which gave 3·40 per cent. The graphite which separated, on treating the finely powered rock with pure hydrofluoric acid and sulphuric acid, and boiling the residue with water, was apparently in a pure state, but on ignition for nearly two hours left a considerable ash.

as is usual in such cases, this is associated with an exclusion of iron, which has been deposited as magnetite adjoining them and also in neighbouring fissures. Muscovite is in rather more amount than the other mica in lath-shaped flakes. In this mass are some minute crystalline grains, which are colourless, have a wrinkled surface, strong marginal total reflection and polarize with red and green tints of the first order of colours. I found one such crystal which had a prismatic form, and which obscured parallel to the sides. These data seem to indicate zircon.

(*b.*) The schists here are a little more altered, and have micaceous nodules. They are vertical on a strike of N. 80° W.

(*c.*) Rather coarse schists having a gneissose appearance. The strike is probably N. 60° W., the beds being vertical. In a microscopical examination, I found this rock to be composed of much quartz in grains, alkali mica in aggregates of small flakes, together with a little brown magnesia mica.

A dyke crosses the beds at this place. The ground mass of the rock was probably felspathic, but it is now greatly altered into a pale green-coloured fibrous chlorite. In this ground mass are a few much altered felspars, in which no striations are distinguishable in more than traces. There are also chlorite pseudomorphs after some mineral, possibly augite. This dyke may be a porphyrite, but it is so much altered that a satisfactory diagnosis is not to be arrived at.

(*d.*) At this place the schists are in a still more altered condition than those seen last on the line of section. They have an appearance resembling that of a fine-grained gneiss, and they strike N. 45° W. A sample of one of these schists, when examined as a thin slice under the microscope, I found to be composed of quartz and mica in about equal amounts, but in places the former predominates slightly, while in other places the contrary is the case. The quartz is in angular grains of the character usual to some metamorphic schists. It has very few fluid cavities, but it includes numerous minute oval or rounded microliths of a brown colour, which appear to be mica. The mica in this rock is of two kinds, first a colourless alkali mica either in individual crystals or in masses of flakes or small scales, which are then surrounded by brown magnesia mica.

Throughout the slice there are masses of iron ore, which in some instances are clearly aggregates of imperfect crystals. These masses also include flakes of muscovite.

(*e.*) The schists at this place are very massive, no bedding being visible and only indistinct foliation in the rock. I found a sample, of which I prepared a thin slice, to be very micaceous, most of the mica being a yellowish or colourless alkali mica, the colourless portion being either in plates or else in plumose or fan-shaped groups of plates. The yellowish-coloured mica is fibrous, or is in small scales, and it fills in spaces. This yellow fibrous mica also surrounds other minerals, and seems to be due to later alteration, and has some resemblance to damourite. There are also numerous patches of pleochroic brown mica in which I observed in places minute crystalline inclusions, round which there is a dark to black halo which disappears when the slice is rotated, so that the traces of the basal cleavage are perpendicular to the plane of the polarizing nicol. The pleochroism of the halo is only visible in the vertical sections of the mica, and not in those which are parallel to the basal cleavage, in which the inclusion is surrounded and concealed by a permanent circular opaque black patch. In these latter sections the dark halo is seen, but it undergoes no change in rotating the slice. In connection with these phenomena are to be noted numerous crystals and grains of iron ore, or possibly ilmenite, although in no case did I observe any of the characteristic alteration products of that mineral.* Many of these crystals of ore can be recognised as being hexagonal, but in most cases the outlines of the crystals are eroded or worn away; other cases are where there are mere skeletons of crystals, part of the form being indicated merely by minute black grains in rows. These ores are connected in some cases with the brown mica, and with the halos surrounding the microliths of which I have spoken. These observations suggest that the pleochroic halos may be due to local molecular aggregation of iron in the mica.†

As is usual in other parts of the district, there are two alternating varieties of these schists, one of which is more quartzose than the other.

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* Minute portions of iron ore which I extracted from the powdered rock did not give me any reactions for titanium when examined with fluxes before the blowpipe.

† Rosenbusch notes these occurrences in mica, and suggests the above explanation in his "Physiographie der Mineralien," 2nd edition, p. 192.

The main mass of a slice prepared from a sample of the quartzose variety I found to be composed of almost equal sized grains of quartz and felspar, the former being the more plentiful. There are also here some grains of quartz of much larger size than the average, and these are all much broken. All the quartz grains, large and small, have numerous fluid cavities, and also include numerous small reddish-brown flakes of mica.

By far the greater number of the felspar grains are simple, and appear to be orthoclase. The few which are compound I consider to be oligoclase near to albite, if not indeed the latter. They much resemble similar felspar grains which occur in some of the quartzose schists at Ensay.

In the mass of the rock which is thus composed of quartz and felspar there is an amount of mica equal perhaps to one-fifth of the whole. The greater part of the mica is a yellowish to light-brown magnesia mica, not strongly pleochroic, the remainder being muscovite. The mica lies between and around the grains of quartz and felspar, and has, as it seems to me, been formed later than either of them. A few yellowish tourmaline crystals, with a few small grains of magnetite, (?) complete the composition of this rock.

It is to be noted that in these schists, which adjoin an intrusive mass or large dyke of aplite, felspar and tourmaline appear, and that the schists generally have assumed a structure and composition differing in a marked manner from those at (*a*) which were taken as a starting point, because they were a fair example of the mica schists which extend from the Bowen Mountains across towards Hinnomunjie, and which are perhaps also representative of the metamorphism of those strata generally anterior to that further alteration which was produced by the granites.

(*f.*) There is here an exposure of a mass of granite. The surrounding schists are much contorted, and are spotted and micaceous. The sample of schist which I examined from this place is fine grained, and composed of numerous grains of quartz, among which are small flakes of a brown mica and of muscovite. The mica has in places a parallelism, and thus produces the appearance in the slice of foliation. A few light-coloured grains of tourmaline complete the rock. The granite is rather light-coloured, and is composed of felspars, mica, and quartz. The principal felspar is orthoclase in irregularly bounded crystals, which in some cases include veinlets of a second felspar, thus being a microperthite. In one instance I found the felspar intergrown with quartz in the "graphic" manner. Some of the orthoclase felspars are quite fresh, while others are converted into pinite pseudomorphs, accompanied by the usual large plates of muscovite mica which I have observed in such cases in some of the Ensay rocks. That these pseudomorphs are after potassa felspar is shown by portions remaining centrally in one or two cases still unaltered. A few triclinic felspars occur also in smaller crystals, having small obscuration angles. Some of the crystals of muscovite are probably original, whilst others are certainly secondary, as, for instance, the micaceous aggregates of the pseudomorphs.

Brown, strongly pleochroic magnesia mica appears also to be one of the earlier-formed minerals, as it is extensively eroded, and has ragged edges, portions of which have, in places, been detached. The same pleochroic halos surrounding minute crystals, of which I spoke a few pages back, appear here also under the same conditions. Here also such of the minute included crystals which I could examine had a prismatic habit, with rounded edges, and a longitudinal obscuration. Their comparative rarity and their minuteness, so far, have prevented me from isolating any for separate examination, and their real nature must therefore still remain uncertain. This granite mass is about thirty paces across on the line of section, and then the schists continue much broken up, disjointed, and in places decomposed.

(*g.*) The schists at this place are very massive, and are traversed by small veins of aplite and of quartz. They are jointed, but the bedding is obscure, if not obliterated. In a hand sample the rock is buff-coloured, with a schistose structure, and under the lens it has the appearance of being a rather minute mixture of yellowish-coloured felspar, quartz, and mica. Under the microscope I found this rock to resemble in its structure that described at (*e*), but it is rather coarser in grain, and with fewer felspars as compared to the quartz grains. The felspars form connected veins of varied width, separating the quartz grains into rude foliations connected with each other. Muscovite mica occurs in crystals among the felspars, and seems to be one of the earlier-formed minerals. There are also a few light-coloured flakes of magnesia mica, and a few greenish prisms of tourmaline complete the composition of this rock.

(*h.*) At this place the schists are much jointed, and the foliation is not marked; yet, on looking at the rocks in mass, they can be seen to be contorted in structure. A rude foliation dips at 52° to N. 20° E. There are traces of granite veins with schorl. The hand sample of this rock is of a light buff colour, with a schistose character produced by alternations of light and dark-coloured foliations. Examined by means of the pocket lens, the light-coloured portions appear to be a minute mixture of felspar and quartz, and the dark-coloured portions to be the same with a large proportion of a dark-coloured mica. Throughout this surface larger plates of muscovite are visible.

This preliminary diagnosis is borne out by an examination of a thin slice. The main mass of the rock is composed of quartz and mica, with a somewhat less amount of felspar in grains. In places these grains are aggregated together, and are surrounded by grains of quartz larger in size. These felspar aggregates suggest that they are the broken fragments of one individual. The grains of quartz are much separated by flakes of muscovite and of magnesia mica, the latter being much chloritised. This chlorite polarizes with faint tints. The quartz grains include fluid cavities, and also numbers of minute, rounded, brown and colourless microliths. Iron ores and a few broken and cavernous crystals of tourmaline complete the list of component minerals.

(*i.*) The schists here are thick bedded, dipping S. 65° W. at 78°. In a hand sample the appearance is much that of the last described rock, but it is rather darker in colour, and perhaps not quite so minutely crystalline.

In a thin slice the rock is seen to be mainly composed of interlocking grains of quartz, which are full of rounded microliths, both of a brown colour and colourless. Brown mica flakes are plentiful among the grains of quartz. In places, what may be called the ground mass of the rock, is not quartz, but felspar, in which are included the quartz grains. Most frequently this felspar has been converted into an aggregate of minute flakes of mica of a yellowish colour. In addition to these components there are a few yellowish-coloured tourmaline crystals, which, as in other samples of these rocks, have been eroded and wasted since their crystallisation.

(*k.*) The schists at this place dip N. 20° E. at 81°, and are traversed by small aplite veins. The sketch, Fig. 3,

Plate II., gives roughly the features of these beds. A sample from the bed marked (*a*), which I examined in a thin slice, I found to be foliated by alternate bands of brown pleochroic mica and quartz in crystalline grains. The interspaces are filled by a mixture of flakes of brown mica and a lesser number of flakes of muscovite, or else filled by small masses of pinite, with relatively large plates of muscovite. As in other rocks in this section, the brown mica contains, but not in all cases, minute inclusions surrounded by pleochroic halos. In addition there are also grains of orthoclase among the quartz grains.

A second sample which I examined was from one of the finer-grained beds (*b*), which, here as elsewhere in this district, alternate with those which are quartzose. I found it to differ from that last described. It has a well-marked foliated structure. The greater part of the slice has, at one time, been a ground mass of orthoclase felspar, in which were included grains and irregular patches of quartz, thus producing a structure resembling that which is termed "graphic" in the granites. In the greater part of the slice the felspar has been converted into a colourless or slightly yellow alkali mica, while, in other places, the felspar is still unaltered. This felspar appears to be orthoclase. The areas of felspar and quartz or of mica and quartz are separated by foliations of brown mica with a little muscovite. In places the foliations bulge out round small masses of felspar and quartz with a little mica, simulating, on a small scale, the so called "eyes" in some rocks. In some of the felspar areas there are places where the brown mica preponderates, in others, it is the muscovite together with small grains of quartz. A few small crystals of tourmaline are scattered throughout the mass. There are also a few scattered crystals of iron ore, having traces of hexagonal outlines. Most of these are in the neighbourhood of the brown mica, of which some individuals have pleochroic halos.

In this rock the felspar and quartz appear to have crystallised almost simultaneously, forming a ground mass in which are the micas and the iron ores.

(*l.*) The schists, which up to this place were much as last described, become here more massive, but with traces of bedding, and an apparent strike of N. 40° W. They are also traversed by small winding veins of aplite and quartz.

(*m.*) The rocks at this place are massive and much jointed, and are traversed by a strong dyke of "graphic granite," nine to ten feet in thickness, and striking N. 10° E. There is also here a strong dyke of basic rock on the same strike, which I did not further examine.

The crystalline granular character of these rocks raises a doubt whether they may not be, in fact, members not of the schist group in a metamorphosed condition, but of the granites. Yet their resemblance in some respects to portions of the most altered of the schists which I have described, and the absence of any defined contact, cause me to hesitate as to the class to which I should assign them. I shall again refer to this, after describing the remainder of the section, and I now proceed to give some data as to the mineral composition of these rocks at (*m*).

The dyke of "graphic granite" is a good example of one of the extreme forms in which the granites of this neighbourhood not infrequently occur. It seemed to me to be worth further examination. It is light-coloured, or of a light yellowish tint. It has a platy structure in places, due to a tendency to split along the cleavages of the felspars, which are similarly oriented over considerable spaces, for instance, over several inches square. The larger part of the rock seems to be felspar, and the lesser part quartz, in grains and in veinlets, producing in the planes of separation those figures which have given a name to this kind of rock. Where there are fissures traversing the rock, secondary muscovite has been produced.

Examined in a thin slice, I found this rock to be composed of microcline and quartz, with a very little secondary muscovite mica. The microcline is twinned in the well-known manner, and contains portions which are not twinned, and which re-act with polarized light, as does the monoclinic potassa felspar. Albite is in considerable amount, and occurs in veinlets, in small twinned crystals in the microcline, and more rarely outside of it. The quartz has no crystalline form, but is in irregularly-shaped masses, such as are well known in graphic granite. The rock is traversed by fissures which have been filled partly by the comminuted felspar, and partly by secondary muscovite resulting therefrom. Round some of the quartz grains there are radiating cracks and disturbances of the microcline twinning, indicating strains.

On these data, this rock may be described as a graphic granite, and from its occurrence as a dyke at this place, may be considered allied to, but, in all probability, younger than the aplites.

A quantitative analysis which I made of this rock is given below :—

ANALYSIS NO. 7.—GRAPHIC GRANITE.

$Si.O_2$	...	...	...	70·91
$Al._2O_3$	...	...	...	15·32
$Fe._2O_3$	...	...	...	tr.
Ca.O	...	...	...	·58
Mg.O	...	...	...	·07
K_2O	...	...	...	10·07
$Na._2O$	...	...	...	2·31
H_2O	...	...	...	·51
				99·77
Hygroscopic Moisture			...	·15
Sp. gr.	...	...	...	2·564

(*n.*) Here are massive crystalline granular rocks with aplite veins. A strong dyke of this rock traverses them, dipping probably N. 20° E. about 40°. A hand sample from this place is very fine grained and siliceous, and has no resemblance to the thick-bedded schists which I have described at (*i.*) These rocks resemble some of the crystalline granular parts of the bedded schists, but are themselves only faintly schistose in places ; whilst in others there are crystalline granular patches of small size, whose composition of felspar and quartz, with but little muscovite, approximates in appearance to aplite, while it shades off also into the surrounding rock. I must leave for future determination the exact relations of these rocks to the schists on the one hand, and to the intrusive granites at no great distance on the other ; but I may point out that it may be possible that we have here an instance in which the sediments under the influence of the exudations from the plutonic magma have more or less, in re-crystallising, assumed their character. I have long since seen, and have pointed out, that large masses of the lower parts of the Silurian sediments must have been absorbed by the plutonic magmas.

(*o.*) From (*n*) to this point there are but few rocks visible, and they are all of a massive appearance. A sample collected at (*o*) proved, on examination as a thin slice, to be interesting. There is in it a ground mass, which is formed in places of orthoclase felspar, which surrounds and includes rounded or sub-angular grains of quartz, and this is analagous to the structure of the rocks lately described. In places the quartz also surrounds portions of felspar. Most usually the felspar has been converted into small flakes of alkali mica, which lie at various angles to each other. The result simulates portions of mica schist enclosing quartz grains. On the whole this rock is very quartzose, the grains being angular to rounded, and in places showing strain. Between the grains, and also bordering the felspar, there are in places small flakes of brown mica which extend down into fissures, and which are, therefore, probably secondary in formation. There are in this rock hexagonal and imperfect crystals of iron ore, and also a few scarce crystals which I refer, upon grounds before stated, to Zircon.

At about two hundred yards from this spot is the boundary of the Granites, and there being on the one side massive rocks with faint traces of foliation, and on the other well-marked porphyritic granites. I have here marked on the section a second possible contact (x'.) In order to compare the doubtful rocks with the porphyritic granites which they adjoin on the north-east side, I made a quantitative analysis of both samples. The first to be described is the one on the north-east side—that is to say, on that side on which the schists are found. The sample is a rather fine-grained, crystalline granular rock, dark grey in colour, with in places lighter portions, giving it a slightly schistose appearance.

An examination of a thin slice of this rock gave me the following results, and I found it to be composed of the following minerals :—

(*a*.) Orthoclase in eroded crystals, most of which have been much altered to muscovite, which either is scattered through the crystal or entirely replaces it. In parts the orthoclase crystals have been broken up, and much of the resulting *debris* has gone to produce mica. The orthoclase was formed before the triclinic felspars, which have been altered in an analogous manner to the former. The low extinction angles of the plagioclase indicate albite or oligoclase. Muscovite occurs not only as alteration products replacing felspars, but also as larger flakes and crystals of an earlier formation. Intergrown with the muscovite, but also independently of it, is a brown pleochroic magnesia mica which, where unaltered, is much corroded and "tattered," and where altered, has been converted into a pale-coloured chlorite. As is very common in this chloritisation, the process has also eliminated iron ore. The greater part of the rock is composed of quartz grains, which have been crystallised last of all.

The subjoined analysis is of this sample :—

Analysis No. 8.

P_2O_5	·06
$Si.O_2$	69·79
$Al._2O_3$	16·47
$Fe._2O_3$	·53
Fe.O	2·97
Ca.O	·73
Mg.O	1·95
K_2O	3·44
$Na._2O$	1·68
H_2O	·99
	98·61
Hygroscopic Moisture ...	·49
Sp. gr.	2·720

Close adjoining this rock is the boundary of the granites, which are porphyritic with orthoclase felspars. A sample which I collected close to the boundary is a light-coloured crystalline granular rock, of medium texture, containing two micas, felspars, and quartz, and with porphyritic crystals of rather greasy-looking orthoclase.

A quantitative analysis of this sample is as follows :—

Analysis No. 9.—Granite.

P_2O_5	·05
$Si.O_2$	68·87
Al_2O_3	16·62
$Fe._2O_3$	·43
Fe.O	2·72
Ca.O	·71
Mg.O	1·60
K_2O	6·48
$Na._2O$	1·80
H_2O	·74
	100·02
Hygroscopic Moisture ...	·21
Sp. gr.	2·762

An examination of a thin slice of this sample by the microscope shows that it is composed of two kinds of mica, two felspars and quartz, and that, therefore, in accordance with the classification of Rosenbusch, which I follow, it is a granite.

The crystals of orthoclase are larger than those of the accompanying plagioclase. They are also more converted into mica. Instances occur of intergrowth with quartz. Various stages of alteration can be followed out in this slice, from a conversion of the edge of the crystal more or less into muscovite, to the complete conversion into that mica. Intermediate stages show portions of felspar still intact. In one eroded crystal, the section of which was approximately parallel with OP (001), I observed a number of angular fragments of plagioclase. These had the appearance of being parts of a former whole, and if so, would indicate more than one generation of triclinic felspars. For the plagioclase crystals in this rock, which are subordinate in number to those of orthoclase, are better formed, are smaller, and are less altered, and may, therefore, be considered as formed at a later period than the orthoclase. The obscuration of these triclinic felspars indicate oligoclase rather than albite.

In one or two instances I observed the environment of a simple crystal by a margin which was twinned. Muscovite mica is in a few large crystals which appear to be of an older generation than the remaining small flakes, or aggregates of flakes, which are certainly alteration products. Yet even some of the larger flakes of muscovite extend into the felspars.

The magnesia mica is brown in colour, and distinctly pleochroic. It was one of the earlier-formed minerals, but is present only in small amount. The crystals are in places crushed and broken, and the isolated flakes are tattered or torn across, and in the latter case I observed, where the fracture was filled in with minute flakes of muscovite. This mica has in some cases dark pleochroic halos surrounding microliths such as I have before described.

An inspection of the two analyses, Nos. 8 and 9, shows a great similarity of composition, and this, together with the mineral composition of the two rocks and their proximity to each other, strongly suggests the conclusion to which I have before referred, that the crystalline granular rocks shown between the letters (x) and (x') in the section may, perhaps, be unusual forms, in which the intrusive rocks have crystallised. For the present I must leave this in a state of doubt.

At this point the diagram section terminates, but the granites extend westwards, without break, along the course of Wilson's Creek, to its junction with Livingstone Creek, and thence to the hills on the western side. When examining these hills, I found that the granites still extended, with slight alteration of composition, and that in places they assumed a gneissose structure. But I did not, within a distance of about two miles from Livingstone Creek, meet with even any traces of such schists as those which I have described as being on the north-eastern side of the contact. How far to the west the granites extend, I am at present not able to state.*

The porphyritic structure of the granites of Wilson's Creek is well marked, and on the western side of Livingstone Creek the felspar, which is the porphyritic mineral, is in places remarkably fresh and unaltered. I examined one of these felspars, with the following results :—

ANALYSIS NO. 10.—ORTHOCLASE *(Microperthite).*

$Si.O_2$	63·60
$Al._2O_3$	20·20
Ca.O	·31
Mg.O	·15
K_2O	8·05
$Na._2O$	6·43
H_2O	·52
	99·26

In this felspar the optic axial plane is perpendicular to the plane of symmetry, with horizontal dispersion, as is usual in orthoclase.

In a thin slice prepared from a basal cleavage plate, the main field obscures parallel to the edge P.M., but there are places which obscure at an angle of about 3° from that direction. Small interpositions of quartz and of a second felspar are in veinlets, and also in the direction of the prism, ∞ P. (·110). The felspar veinlets are probably albite, and do not differ from analogous interpositions in some of the

* This examination does not refer to the country south of the junction of Day's Creek with Livingstone Creek.

microperthites, except in so far that they are very minute and in small amount. When the slice is placed in such a position that the plane of vibration of the orthoclase is parallel to that of the polarizer, the nicols being crossed, and the field therefore obscure, the space surrounding any one of the quartz inclusions depolarizes the ray, and permits light to pass. But in the space thus illuminated a black cross shows, whose arms are parallel to the ortho and clino-diagonals respectively. On rotating the slice some 3° from this position, the arms of the cross close together into a black bar having that direction, the field still being light. These appearances indicate that the felspar surrounding the quartz grain is in a state of strain.

A slice prepared from the second cleavage, namely, parallel to the clino-pinnacoid, shows the familiar appearance of minute veinlets of the second felspar (albite), which cross the trace of the perfect cleavage at an angle approximating to 65°. The potassa felspar in this slice obscures at 5° 20′ referred to the same datum.

These appearances explain the occurrence of soda in the analysis, although the percentage found is larger than I should have expected from the inspection of the two slices which I prepared.

The felspar is an orthoclase, intergrown with a proportion of albite, after the manner of the microperthites.

It will now be advantageous to summarise the results to which these descriptions of the rocks lead me, first commencing with the schists:—

The schists which I have described occur only on the north-eastern side of the contact, and extend thence for some miles towards Hinnomunjie, the Omeo Plains, and the Bowen Mountains. On the south-western side of the contact there are no schists similar to these, but such as can be found are of a more gneissose structure, with only subordinate traces of mica schist.

When the country is examined for a distance from the contact on its eastern side, the inference seems to be justified that the schists are the metamorphosed representatives of a sequence of sedimentary formations, which can be seen in their least altered forms in the Bowen Mountains; more especially on the eastern sides of these mountains, where, between Tongeo and Bindi, they have the appearance of the Silurian formations, and are at any rate in a highly inclined position, and stratigraphically inferior to the Devonian formations at Bindi.

The general appearance of the regionally metamorphosed members of this sequence of beds, as seen at the Omeo Plains and at the upper part of Wilson's Creek, is that of a series of fine-grained and sometimes nodular or spotted mica schists, approaching phyllites in places, and which alternate with fine-grained to coarser quartzose beds, all being tilted at high angles of dip, on an approximately north-western strike. This amount of metamorphism decreases towards the Bowen Mountains, and increases towards the fault. It becomes especially marked near the contact, or where, as at Wilson's Creek, there are outlying patches of the intrusive rocks. The distance to which the increased amount of metamorphism extends, varies. It may be taken at about a quarter of a mile, at Hinnomunjie Morass, while at Wilson's Creek it is not less than a mile. This increased alteration is shown also by the presence in almost all the samples which I examined from the altered zone, of microscopic crystals of tourmaline in great numbers. The general change in the schists, which may be attributed to the action of the intrusive granites, seems to have been at Hinnomunjie Morass a more complete crystallisation of the previously (regionally) metamorphosed sediments, in larger plates of muscovite and biotite micas, and the production of numerous crystals of tourmaline.

Analagous alterations occur at Wilson's Creek at a distance of a mile from the contact, but are there partly due to the influence of strong masses of granite outlying from the contact. The changes seen in proceeding towards the contact at Wilson's Creek, are the appearance of grains of felspar in increasing numbers; the formation in portions of the schist of what I am inclined to term a "ground-mass" of orthoclase and quartz, and the increasing silicification of the rock.

Finally, there are for some little distance from the margin of the porphyritic granites, a set of crystalline granular rocks, which in some respects resemble both series, and as to which I am unable at present to determine to my own satisfaction, whether they are re-crystallised schists re-acted upon by the granitic exudations, or abnormal forms of the intrusive rocks.

Certain distinctions may therefore be made between the metamorphic rocks in this locality. The first group includes the regionally metamorphosed schists on the eastern side of the contact; the second group includes the more strongly metamorphosed mica schists, with tourmaline crystals and the gneissose schists at Wilson's Creek. The alterations in the second of the above groups I attribute to metamorphism produced by the intrusive granites, and by the younger porphyritic rock-masses connected with them. Thus in one sense the metamorphic rocks adjoining the contact might be not inappropriately spoken of as "contact schists," if it is desirable to limit the use of the term "regionally metamorphic," to those schists whose peculiar mineral and physical composition, and structure, are the result of dynamical metamorphism.

The intrusive rocks in the area herein dealt with are granites, whose western extent I have not determined. This mass of granite has associated with it marginal masses and strong dykes of muscovite granite, passing in places into aplite. These are clearly younger than the main granite mass, as are also other dykes of pegmatite, aplite, and graphic granite, which are found at the contact or beyond it in the schist area. The granites, therefore, taken as a whole, including all the above varieties, represent an intrusion of plutonic rocks of several consecutive ages of the same period of plutonic invasion, and the series is increasingly acid, the later dykes being mainly of orthoclase (micropertbite) and muscovite, or of orthoclase and quartz. Finally, the veins and even strong dykes of crystalline quartz, or of quartz and tourmaline (schorl) which are associated with these granites, represent the last portions of still fluid (uncrystallised) magma.

The line of contact is an irregular one, although the general direction is constant, and approaches the mean strike of the lower palæozoic formations. The invasive rocks protrude into the schist tract in promontories, and appear within it in isolated patches laid bare by denudation, but which no doubt, are connected below with the main granite mass. Thus when we picture to ourselves this mass adjoining the schist contact, and the numerous surface outcrops and veins of granite in the schists, we must see that these all represent a much larger extent of granite subterraneously, which at one time as a magma, invaded the schists both horizontally from the contact and vertically from below, where it "corroded" its way upwards into the schist masses. An inspection of the contacts laid bare by denudation, shows that the intrusive masses now occupy spaces which at one time were filled by sediments, but that their action has not at all times been one of forcible intrusion, for at Hinnomunjie the schists are cut off, but not contorted. At Wilson's Creek, however, their action seems to have been accompanied by more violence and also with greater metamorphic effect, and this may have been due to there having been at that place stronger plutonic activity. For at rather over a mile in a south-west direction from the contact at Wilson's Creek, there is situated a rocky hill, known locally as the Frenchman's Hill, which marks the site of a considerable eruption of igneous rocks younger than the granites, but I believe connected with them. To this younger plutonic magma I attribute the metamorphic action which I observe in some of the granites, and perhaps, also the "finishing touches" in the schists nearest to it. As the granites and the granite dykes penetrated the schists and metamorphosed them, so did the quartz-bearing and quartzless porphyries of the Frenchman's Hill, penetrate in masses and in dykes, both the granites and the schists, and re-act upon them.

It remains to remark upon the gneisses which, in some places, as for instance at the junction of Wilson's Creek, and in a gully on the western side of Livingstone Creek, and nearly opposite Day's Creek, form part of the granitic rocks. These gneisses are in fact merely structural forms of the granites, and are strictly analogous to the gneisses, which in the Swift's Creek area and elsewhere, are often the margins of the intrusive masses. They probably result from pressure upon the consolidating magmas, and it is between gneisses of this class and the plutonic masses that a complete passage can be traced. Where, however, such gneissose forms of the intrusive rocks occur near to contacts with the regional schists in the Omeo district, there appears, unless under most favourable surface conditions, and with the most careful inspection, to be a continuous sequence from the granitic rocks to gneiss, and from gneiss to mica schist, and finally through less altered rocks to the normal lower palæozoic sediments. It is evident that under such conditions, it is only in places where the streams have laid bare a series of such rocks, that the break between the schistose forms of the igneous rocks and the schistose forms of the metamorphosed sediments can be seen and recognised. Examinations elsewhere in places where the actual sequence of the rock formations is obscured by surface accumulations have led to the erroneous belief, which for long I also shared, that there is at Omeo a passage from the granitic rocks to the lower palæozoic sediments, and that therefore the former are the completely metamorphosed forms of the latter.

Where the granitic rocks have no margin of gneiss at their contact with the sediments, and where the latter have undergone very great molecular recrystallisation, the difficulty of a true diagnosis is very great, and questions arise which may require possibly to be revised by the light of more extended examination and research.

In the present investigation, my attention has been attracted more by the appearances suggestive of chemical action producing changes in the sediments, than of alterations brought about by dynamical metamorphism. The effects observed are such as may, I think, be attributed in part to mineral exudations from the plutonic magmas, as also to the volatile emanations therefrom, such as Fluorine or Boron, which have evidently been strongly active at the contacts, and under the exceptional conditions which must have obtained there, have produced a recrystallisation of the already regionally metamorphosed schists. Such results were more marked in the district which I have described in this paper, than those which could be attributed to the compression and dislocation of rock masses subjected to shearing strain. These latter phenomena can be studied better in other parts of the Omeo district, and would properly orm the subject of a separate memoir.

The general conclusions to which the study of the phenomena noted in this paper has led me may be briefly stated as follows :—

(1.) The contact referred to represents an extensive fault, with a downthrow on the north-east side of undetermined depth.

(2.) The schists on the north-east side most probably represent some of the regionally metamorphosed lower palæozoic sediments (Silurian).

(3.) The schists were let down within the influence of the plutonic magmas which invaded them, both horizontally from the contact and from below upwards.

(4.) The regional schists were probably phyllites and fine grained mica schists, and by the further action of the invading granites, have been converted for some distance from the contact into mica schist, tourmaline schist, and forms of gneiss.

(5.) The numerous masses and veins of crystalline quartz which occur at or near the contact, as well as the veins of quartz associated with mica (muscovite), with felspar (microperthite), and with tourmaline (schorl), must be regarded as emanatous from the consolidating granites, and, therefore, as of plutonic origin, and thus, so far as the quartz veins concerns, to be distinguished from the auriferous quartz veins of the district.

(6.) The period of geologic time at which the granite magmas invaded the schists cannot be stated with precision, but it may be broadly stated that it was probably synchronous with the period of plutonic activity in the Gippsland Alps—that is to say, at the close of the Silurian or the earlier part of the Devonian periods.

DESCRIPTIONS OF PLATES.

Plate I.

Fig. 1. Diagram section (horizontal) near Hinnomunjie Morass, about 200 feet in length, at the contact of the muscovite granites with mica schists. (*a*) Alternating beds of micaceous and quartzose schists striking N. 55° W. (*b*) Muscovite granites. (*c*) Tourmaline schist.

Fig. 2. Diagram section (horizontal), about 400 feet in length, near Hinnomunjie Morass, across the contact of the muscovite granites with the mica schists. (*a* and *f*) alternating micaceous and quartzose beds striking N. 30°–70° W. (*b b′*) Dykes of muscovite granite. (*c*) Dyke of metamorphosed basic igneous rock. (*d*) Dyke of muscovite granite, Plate II., Fig. 1.

Fig. 3. Diagram section (vertical) at Wilson's Creek. (*a*) Spotted fine-grained mica schist, alternating with quartzose beds dipping N. 60° E. at 70°. (*b*) Similar beds, but more altered and disturbed. (*c*) Gneissose schists, strike probably N. 60° W. (*d*) Schists resembling a fine-grained gneiss in contact with strong dykes

Plate. I

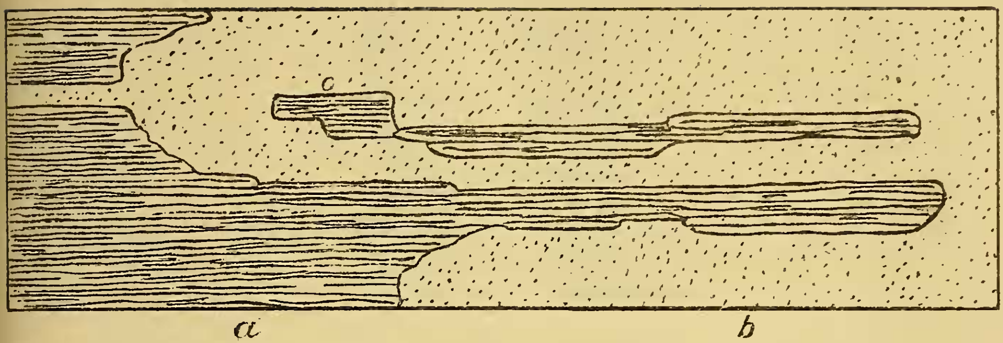

Fig. 1

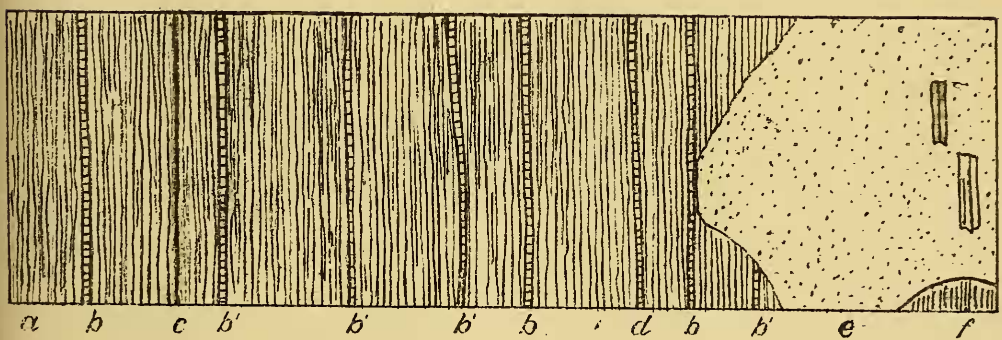

Fig. 2

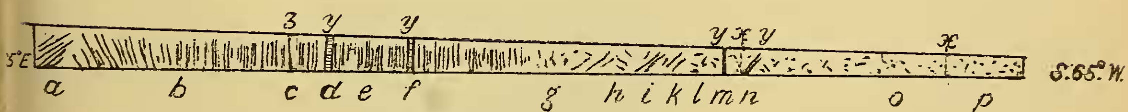

Fig 3